The fastest spinning Galactic pulsar

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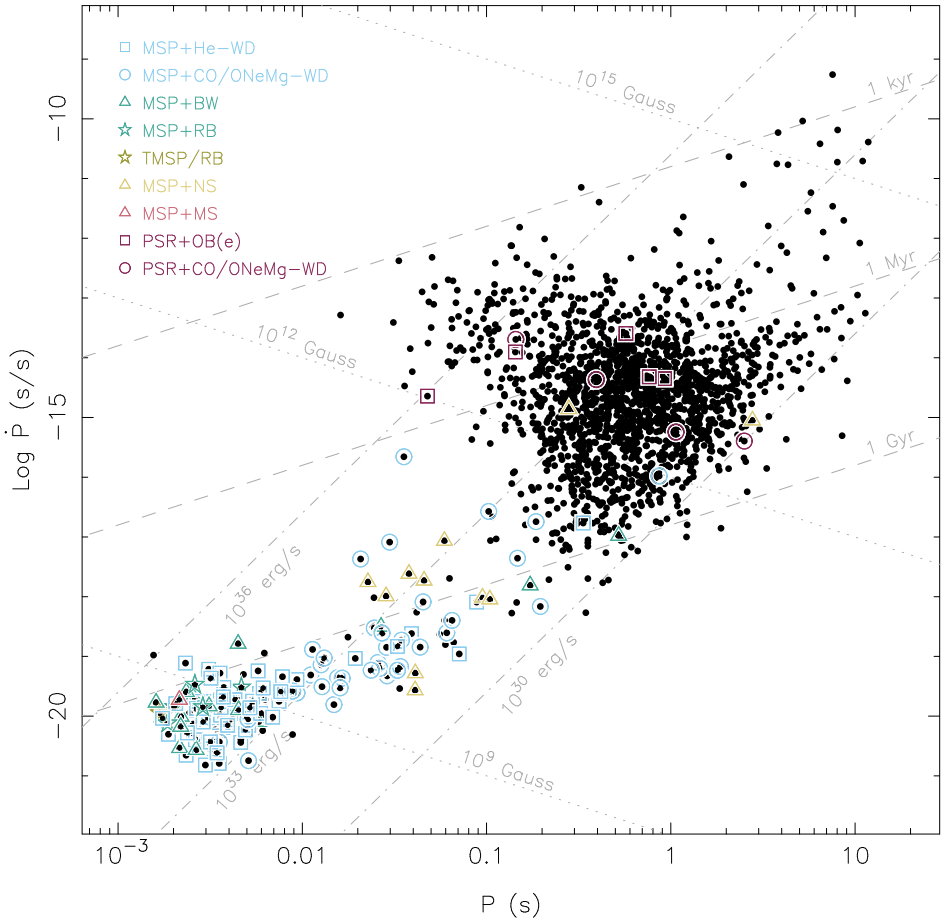
Why search for millisecond pulsars?

MSPs can be used to understand:

- the neutron star equation-of-state
- tests of General Relativity
- binary evolution
- the physics of accretion
- the emission mechanism



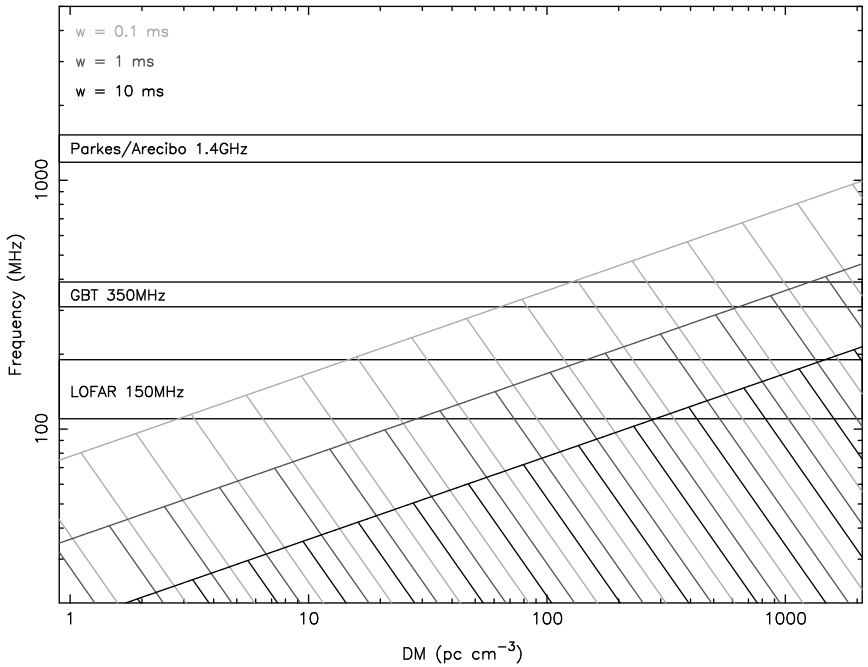
Searching for MSPs with LOFAR

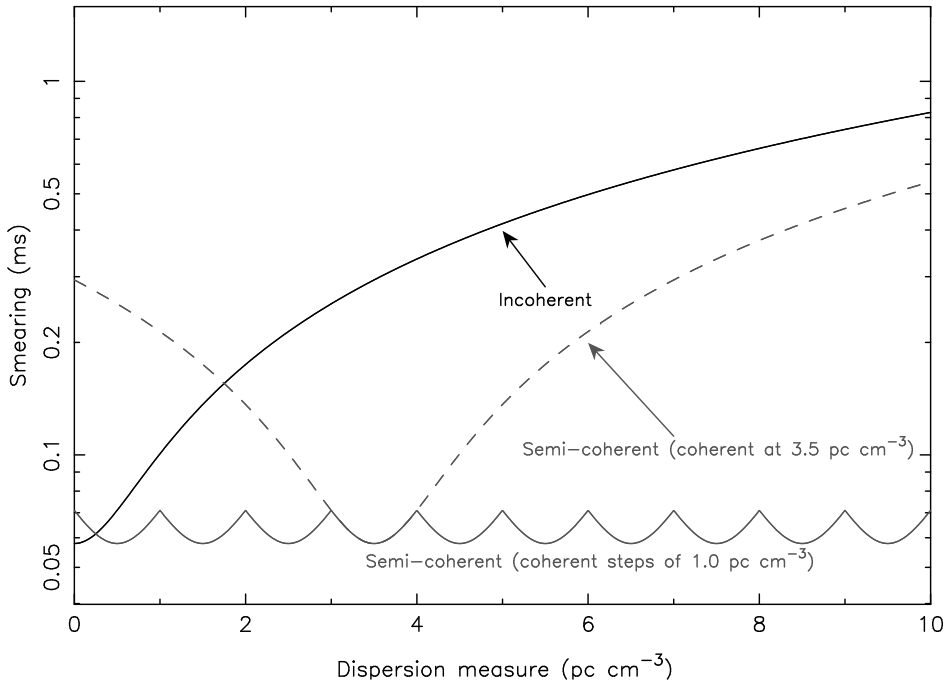
Advantages:

- Steep radio spectra → bright at low frequencies
- Unexplored parameter space

Disadvantages:

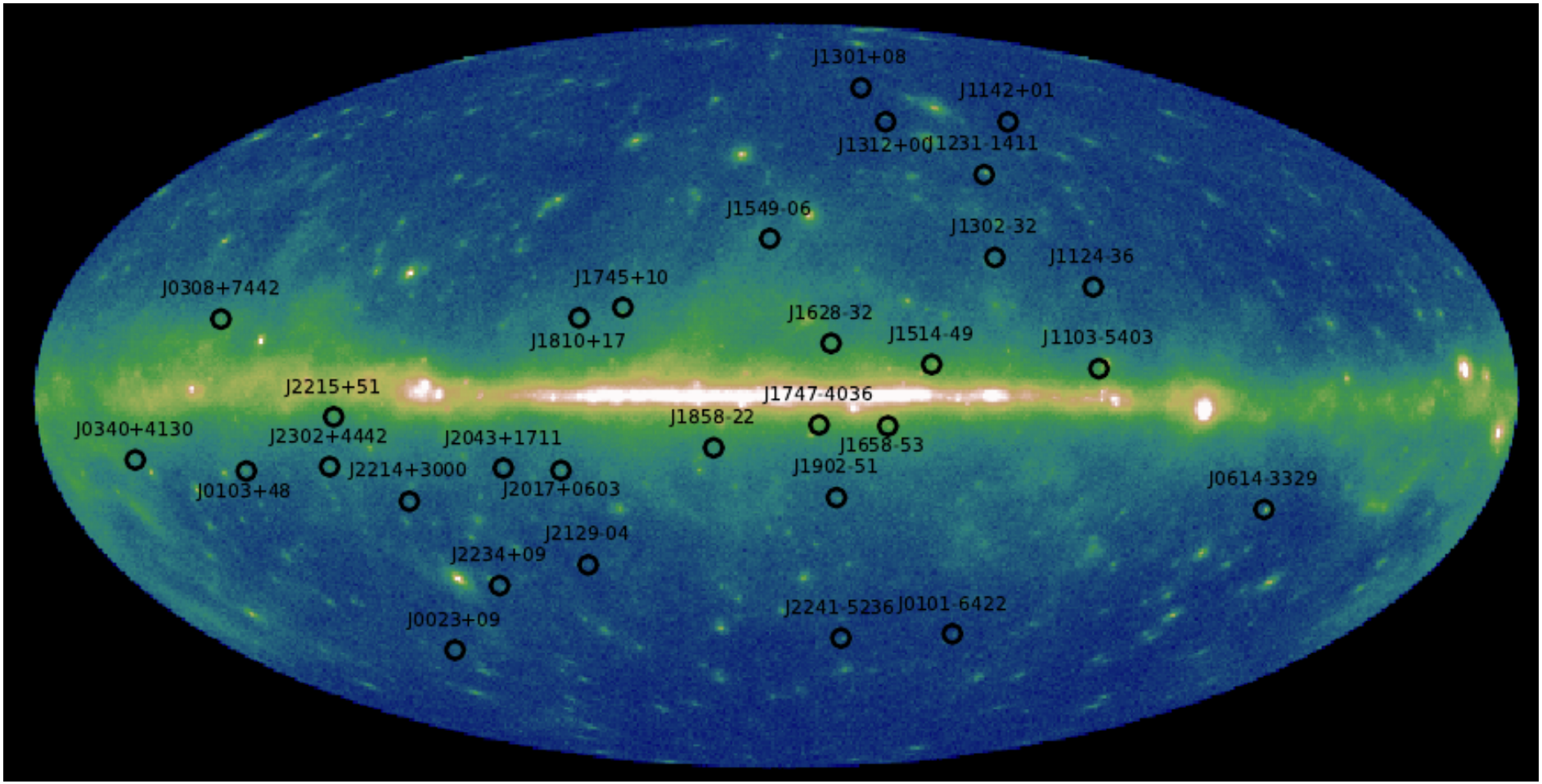
- Interstellar medium (dispersion & scattering)
- High time resolution/data rates required





Semi-coherent dedispersion (Bassa et al. 2017)

Targeted surveys of *Fermi* γ-ray sources



(Scott Ransom)

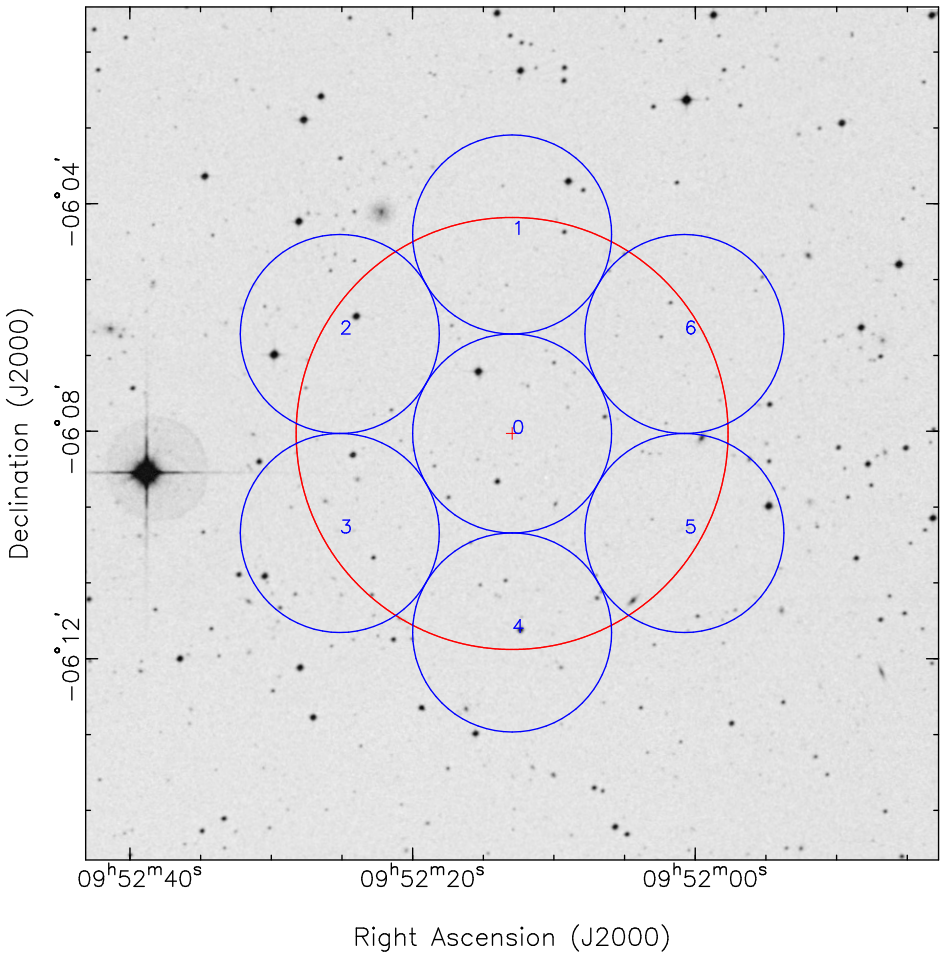
LC7 LOFAR HBA Survey of *Fermi* γ-ray sources

Observational setup:

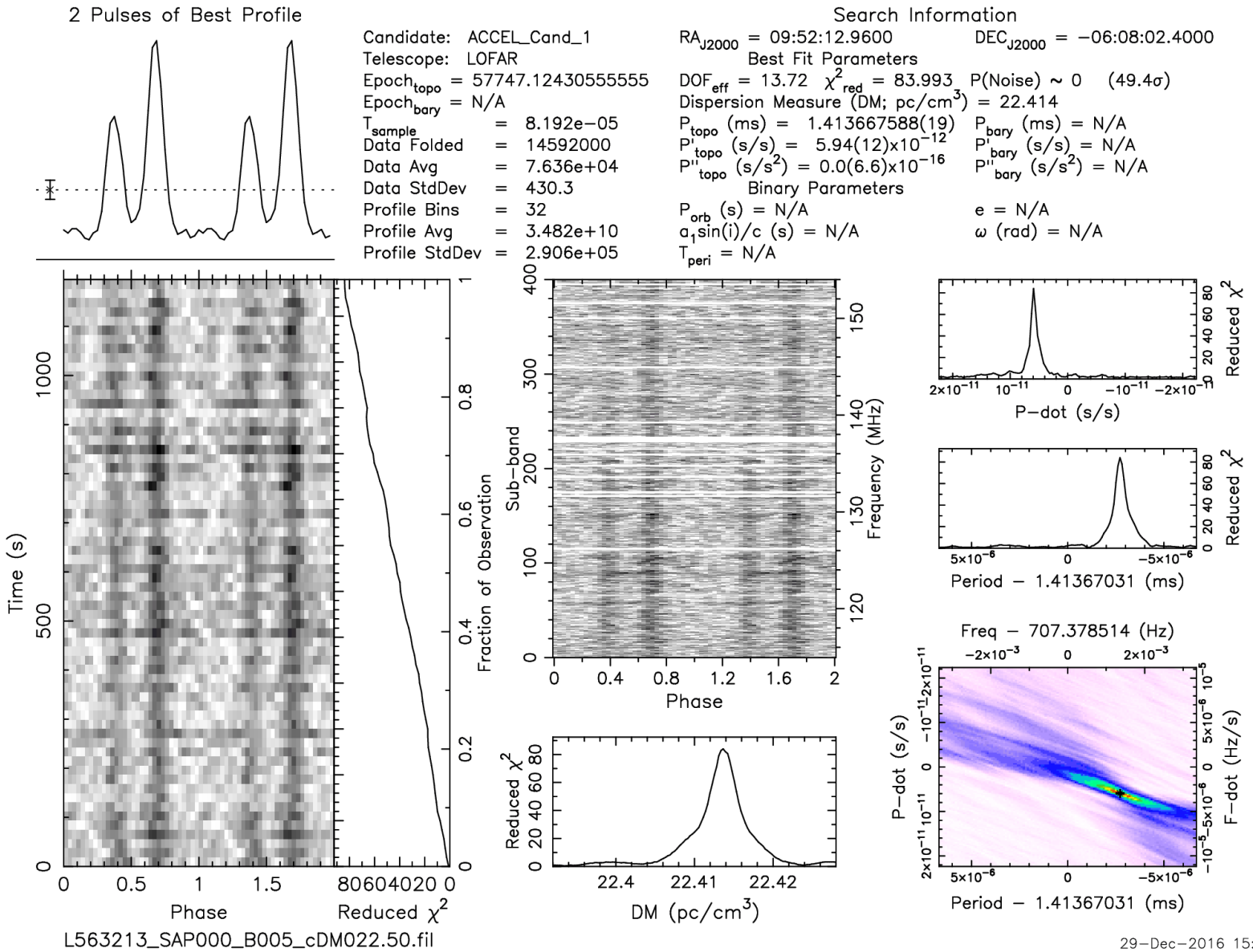
- record complex voltage data
- 7 tied-array beams
- 21 core stations
- 200 subbands (115 to 155 MHz)
- target 23 MSP-like γ-ray sources
- 2×20 min per target

Processing:

- copy from CEP4 to DRAGNET
- redigitize from 32 bit to 8 bit
- coherent/incoherent dedispersion
- frequency-domain acceleration searches



Fastest Galactic MSP!

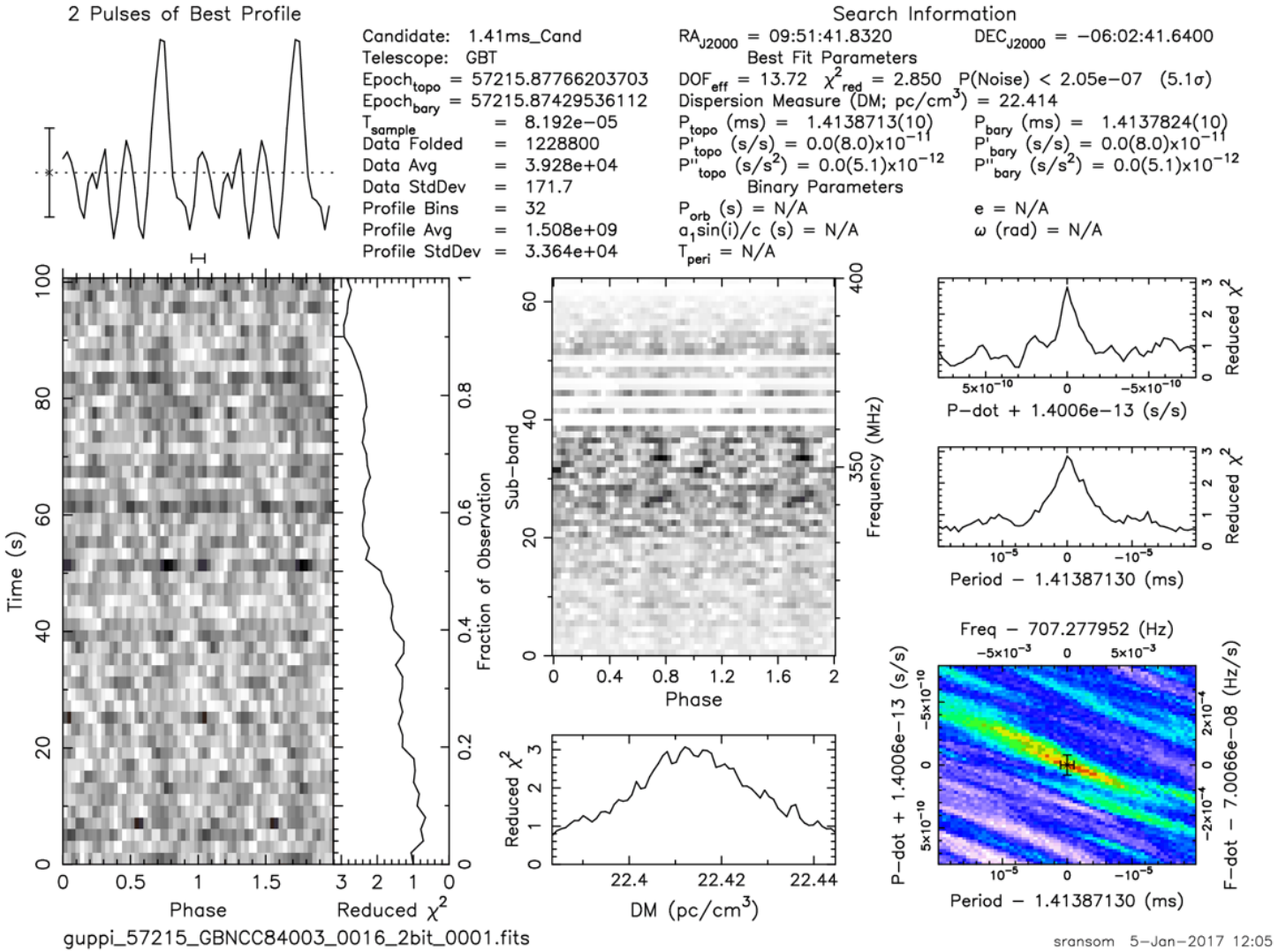


29−Dec−2016 15:25

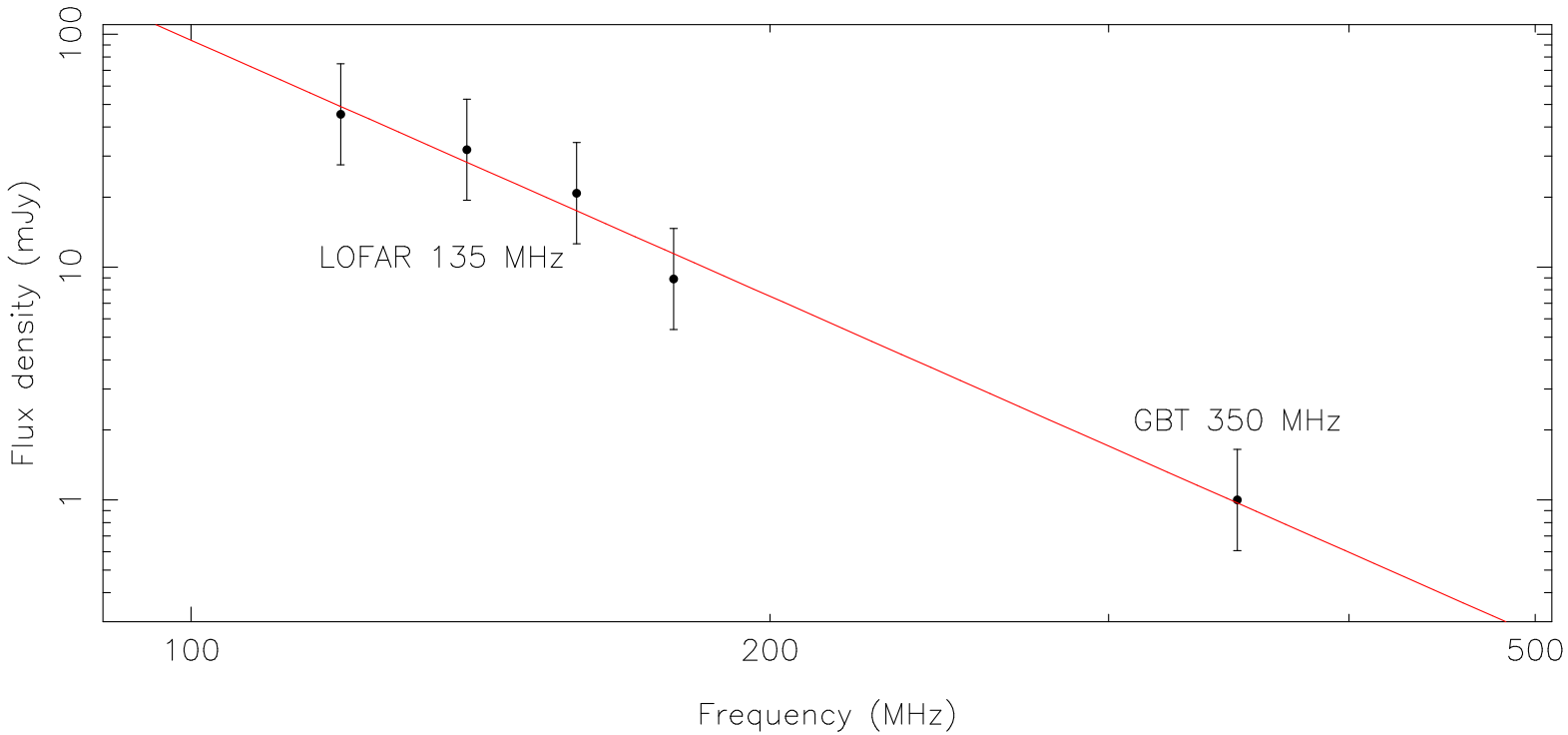
Fastest Galactic MSP!

- **Ter 5ad:** 716 Hz (2005; in globular cluster)
- J0952−0607: 707 Hz (2017)
- **B1937+21:** 641 Hz (1982)
- **B1957+20:** 622 Hz (1988)
- **J1747−4036:** 606 Hz (2009)
- **J1810+1744:** 601 Hz (2009)

GBT 350 MHz detection



Spectrum

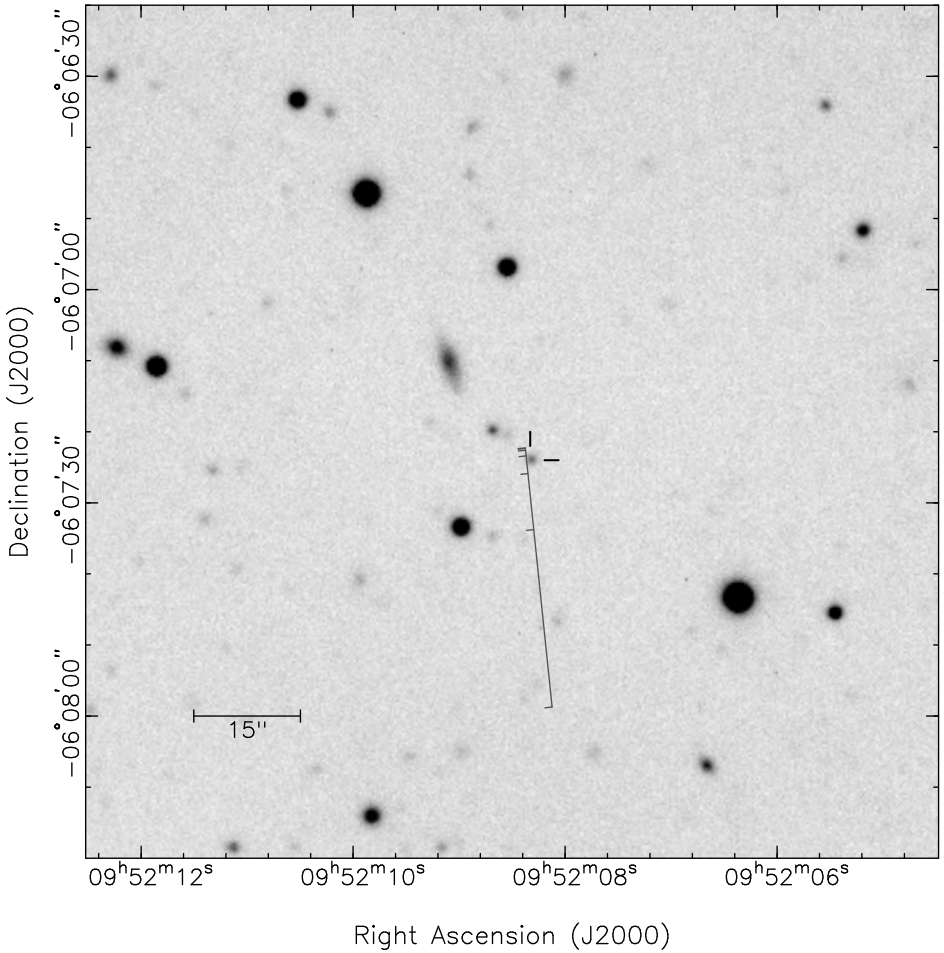


$$S_\nu \propto \nu^{-3.6}$$

System properties

PSR J0952−0607:

- 707 Hz spin frequency!
- DM of 22.4 pc cm^{-3}
- Binary system (6.42 hr, 0.02 $M_\odot$)
- Highly variable optical counterpart
- Very energetic pulsar
- *Black widow* type system
- Extremely steep spectrum
- No radio eclipses!?
- Too faint for LBA...



Summary and ongoing work

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- Discovery of a 707 Hz binary MSP with LOFAR!
- Extremely steep spectrum
- Counterpart identified; spin properties known with 40 days of timing
- LOFAR is ideally suited to find these steep spectrum MSPs (are all fast?)

Ongoing work:

- DDT for GBT 350 MHz to constrain spectrum/evolution of components
- *Swift* X-ray; possible NICER target
- Working on γ-ray timing (with AEI Hannover)
- Write paper before LC8 deadline!

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